

WHAT IS CLAIMED IS:

1. In a system in which a boring tool is used with a drill string having a length which is fed out in a way which moves the boring tool through the ground in a region which includes a plurality of electrically conductive in-ground lines such that one of a plurality of specific positional relationships exists between each line and the boring tool, an arrangement for tracking each specific positional relationship, said arrangement comprising:

a plurality of transmitter means, each transmitter means generating one of a plurality of magnetic fields at least from an underground length of each respective line and each one of said plurality of transmitter means operating at least approximately at a fixed frequency, which fixed frequency is at least approximately the same for all of the transmitter means, for emanating each one of said magnetic fields from each line at said fixed frequency;

detector means carried by said boring tool for detecting a relative change in a particular characteristic of said fields, which characteristic varies for each line as a function of its specific positional relationship with the boring tool as the boring tool moves through the ground within said region, said detector means cooperating with the plurality of transmitter means such that the magnetic field is emanated from each line in a way which permits the detector means to distinguish the magnetic fields from one another so as to individually track the magnetic field emanated by each line;

monitoring means for monitoring a value of at least one parameter relating to the way in which said drill string is fed out; and

means responsive to said detector means and said monitoring means for correlating the detected relative changes in said characteristic of said fields with the value of said one parameter in a way which indicates certain changes in the specific positional relationship between said boring tool and each respective line without the need to establish an actual distance between the boring tool and said line.

2. An arrangement according to claim 1 wherein each said transmitter means operates individually at a predetermined interval such that the magnetic field is emanated from one line at a time.

3. In a system in which a boring tool is connected to a drill string having a length which is fed out in a way which moves the boring tool through the ground in a region which includes a plurality of electrically conductive in-ground lines, an arrangement for tracking a plurality of positional relationships between the boring tool and each of said lines, a configuration comprising:

a transmitter arrangement for generating a magnetic field from said boring tool;

a plurality of detector arrangements, each of which is connected with a respective one of said lines, for detecting a relative change in a characteristic of said field, which characteristic varies as a function of said specific positional relationship between said boring tool and each of said lines as the boring tool moves through the ground within said region;

a monitoring arrangement for monitoring a value of at least one parameter relating to the way in which said drill string is fed out; and

a processing arrangement cooperating with said plurality of detector arrangements for correlating the detected relative changes in said characteristic with the value of said one parameter in a way which indicates certain

changes in the positional relationship between said boring tool and each respective line without the need to establish an actual distance between the boring tool and each line.

4. A configuration according to claim 3 wherein said characteristic is an intensity of said magnetic field and wherein at least a selected one of said detector arrangements is connected to a selected one of said lines for producing a vector sum responsive to said intensity at a particular location of the boring tool for identifying said positional relationship at that particular location.

5. A configuration according to claim 4 wherein said boring tool is oriented in a specific way with respect to said selected line and wherein said vector sum is indicative of said positional relationship with the selected line, irrespective of the specific orientation of the boring tool with said line.

6. A configuration according to claim 3 wherein at least one of said lines is connected by an electrical conductor directly with one of said detector arrangements.

7. A configuration according to claim 3 wherein at least one of said lines is inductively coupled with one of said detector arrangements.

8. An assembly according to claim 3 wherein said transmitter includes an array of antennas positioned in a predetermined way with respect to one another.

9. A configuration according to claim 8 wherein said transmitter further includes a transmission/control arrangement which drives said antenna array.

10. A configuration according to claim 9 wherein said antenna array includes at least three antennas which are positioned orthogonally with respect to one another so as to permit transmission from three orthogonally disposed axes.

11. A configuration according to claim 10 wherein said transmission/control arrangement includes means for selectively driving each one of said three antennas at a different frequency.

12. A configuration according to claim 11 wherein a first antenna is driven at approximately 80 kHz, a second antenna is driven at approximately 100 Hz below 80 kHz and a third antenna is driven at approximately 100 Hz above 80 kHz.

13. A configuration according to claim 10 wherein said transmission/control arrangement includes means for simultaneously driving two of said three antennas 90 degrees out of phase with respect to one another at a predetermined frequency and means for switching said driving means between alternate pairs of said three antennas at a predetermined switching rate such that the transmitter alternately transmits from said three orthogonally disposed axes.

14. A configuration according to claim 13 wherein said predetermined frequency is approximately 80 kHz and said switching rate is approximately 1 kHz.

15. A configuration according to claim 14 wherein at least a selected one of said detection arrangements includes filter means for producing an output signal responsive to an average signal induced on the line by said magnetic field.

16. A configuration according to claim 15 wherein said filter means includes a low pass filter having a roll-off frequency of approximately 100 Hz.

17. A configuration according to claim 3 wherein the boring tool is operated from an operating location remote from said lines, and including indicating means positioned at said operating location and cooperating with said processing arrangement for specifying changes in said positional relationships.

18. A configuration according to claim 17 including a wireless telemetry link cooperating with at least a selected one of said detector arrangements and said indicating means such that a detected value of said particular characteristic is transferred from the selected detecting arrangement to said indicating means via the telemetry link.

19. A configuration according to claim 3 wherein said drill string is fed out at a predetermined feed rate to move the boring tool through the ground and wherein said monitoring arrangement includes means for monitoring said predetermined feed rate and the fed out length of the drill string, and wherein said processing arrangement indicates changes in the positional relationship based on the feed rate, the length of the drill string and said relative changes in said characteristic.

20. An arrangement according to claim 19 wherein said processing arrangement includes means for determining if the drill head is on a collision course with said line and for providing notification thereof.